



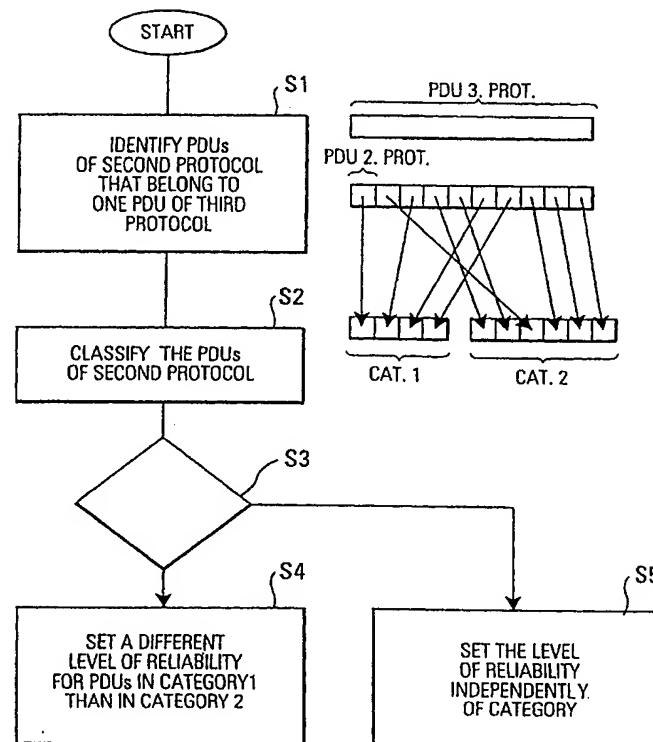
## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification <sup>7</sup> : <b>H04L 1/18, 1/00</b>		A1	(11) International Publication Number: <b>WO 00/24152</b>
			(43) International Publication Date: <b>27 April 2000 (27.04.00)</b>
(21) International Application Number: <b>PCT/EP99/07567</b>		(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).	
(22) International Filing Date: <b>8 October 1999 (08.10.99)</b>			
(30) Priority Data: <b>98119947.4</b> 21 October 1998 (21.10.98) EP			
(71) Applicant: TELEFONAKTIEBOLAGET LM ERICSSON (publ) [SE/SE]; S-126 25 Stockholm (SE).			
(72) Inventors: RATHONYI, Bela; Kiviksg. 8c, S-214 40 Malmö (SE). KHAN, Farooq; 810 Solook Drive, Parlin, NJ 08859 (US). LUDWIG, Reiner; Helga Hoeppner, Im Levert 14, D-52355 Düren (DE).			
(74) Agents: VON FISCHERN, Bernhard et al.; Hoffmann . Eitle, Arabellastrasse 4, D-81925 Munich (DE).			

(54) Title: ARQ PROTOCOL WITH PACKET-BASED RELIABILITY LEVEL SETTING

## (57) Abstract

A communication device and method is provided, for which, when having implementations of first protocol that specifies different reliability levels for sending PDUs of a second protocol, where the second protocol specifies segmentation of PDUs of a third, higher layer protocol, a capability is introduced for setting the reliability level of second protocol (L2\_ARQ) PDUs differently for second protocol PDUs belonging to a defined data structure containing such second protocol (L2\_ARQ) data units. The defined data structure can be a higher layer protocol data unit or the send window. Thereby the delay caused by retransmission of second protocol data units can be reduced significantly.



***FOR THE PURPOSES OF INFORMATION ONLY***

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

## ARQ PROTOCOL WITH PACKET-BASED RELIABILITY LEVEL SETTING

The present invention relates to a communication device and method for data unit based communication, where

5 implementations of at least a first and second communication protocol are used, and PDUs (Protocol Data Units) of a third, upper layer protocol are segmented into PDUs of the second, lower layer protocol, and these lower layer PDUs are sent over a physical connection in accordance with the first  
10 protocol, which provides adjustable reliability levels for the lower layer PDUs.

As is known in the art of communication, protocols are sets of rules with which two points can exchange data units in a  
15 defined way. Two implementations of a protocol at two points that exchange data units are also referred to as peers. For the purpose of the present specification, the term data unit or protocol data unit (PDU) will refer to the finite data carrier specified by a given protocol. It may be noted that  
20 with respect to different protocols, different terms are used for the PDUs. For example, the data units of the internet protocol (IP) are referred to as packets, whereas the data units of the point-to-point protocol (PPP) are referred to as frames. All such terms, i.e. frames, packets etc. fall under  
25 the general term data unit.

Furthermore, the concept of layering different protocols is also well-known. According to this concept, data units of one protocol are embedded into data units of another protocol  
30 when being sent, and are extracted when being received. The term "embedding" refers to both the possibility of encapsulation as well as segmentation.

Fig. 2 shows a generic stack, and the figure introduces a  
35 number of terms that will be used as examples and for explanatory purposes in the following description. The stack

shown in Fig. 2 shows five layers. Naturally, the number of layers can be larger. L3 refers to a network layer protocol, e.g. the internet protocol IP. L4 refers to a protocol above the network layer, e.g. the transmission control protocol TCP. L4 is also to be seen as representing all protocols that may lie above. L2\_Frame refers to a link layer protocol which embeds or frames L3 PDUs, for example the point to point protocol PPP, which is typically used for circuit-switched data in systems operating in accordance with the GSM (global system for mobile communication) standard. Other examples would be LLC (logical link control; defined in standard GSM 04.64) used for GPRS (General Packet Radio Service; defined in standard GSM 03.64) or W-CDMA (wide band code division multiple access). L2\_ARQ refers to a link layer protocol that can segment L2\_Frame PDUs into smaller L2\_ARQ PDUs and implements an automatic repeat request function ARQ on the basis of these L2\_ARQ PDUs. Automatic repeat request (ARQ) means that the protocol supports an automatic retransmission of PDUs under predetermined conditions. Examples of an L2\_ARQ protocol are the radio link protocols RLP used for circuit-switched data in GSM, the radio link control protocol (RLC) used for GPRS and the RLCP (Radio Link Control Protocol) used for W-CDMA.

60

L1 refers to a physical layer protocol or a combination of physical layer protocols that can operate on the basis of single or plural L2\_ARQ PDUs. The L1 protocol is to be understood as a protocol that can provide at least two different reliability levels for the transmission of L2\_ARQ PDUs. Examples of the L1 protocol are FEC protocols (forward error control) or power control protocols, or a combination of both. For example, different L2\_ARQ PDUs can be protected with varying strength of forward error control and/or with varying transmission power. Further possibilities for adjusting the transmission reliability, which may be used individually or combined, are changing the spreading factor

in CDMA or W-CDMA, the interleaving depth, the modulation or the antenna diversity. As these concepts are known in the  
75 art, a further description is not necessary.

It may be noted that the L2\_Frame protocol is optional, as it would also be possible that the L3 protocol PDUs are directly segmented by the L2\_ARQ protocol, without first being  
80 encapsulated into L2\_Frame protocol data units.

Commonly, the L1 protocol will have a general adoption mechanism for deciding on the reliability level that is to be set for each L2\_ARQ PDU. Different known physical layer  
85 protocols provide different adoption mechanisms, e.g. the setting of the reliability level may depend on the quality of the physical link over which data units are being sent.

Such an arrangement can lead to a number of problems. Many L3  
90 protocols and protocols running on top of L3 are sensitive to a delay per data unit and can perform badly or even fail if the delay per data unit exceeds certain bounds. The problem is that when the L3 protocol is running over L2\_Frame/L2\_ARQ or on L2\_ARQ directly, the L2\_ARQ protocol can introduce an  
95 additional delay per L3 PDU, due to the retransmission of L2\_ARQ PDUs. This additional delay is basically unbounded and can cause considerable problems. This will be explained in connection with the diagram shown in Fig. 3.

100 For the following explanation, it will be assumed that L2\_Frame PDUs are being segmented by the L2\_ARQ protocol, but as already mentioned above, it is equally well possible that L3 protocol PDUs are directly being segmented.

105 Fig. 3a shows one L2\_Frame PDU, and this higher layer PDU is segmented into a given number of L2\_ARQ data units. Two of these L2\_ARQ data units are marked as a and b, respectively, for the purpose of a later explanation. As also indicated in

110 Fig. 3a, the L2\_Frame PDU has a given transmission delay,  
i.e. a given length, just as the L2-ARQ data unit has a given  
length or transmission delay.

115 As shown in Fig. 3b, the following problem can occur. If the  
L2\_ARQ data unit a has to be retransmitted, then the number  
of L2\_ARQ data units that needs to be sent is increased by  
one, and correspondingly the transmission of the L2\_Frame PDU  
is delayed by the transmission delay of one L2-ARQ data unit.  
However, if the L2\_ARQ data unit marked as b, which lies at  
the end of the L2\_Frame PDU, has to be retransmitted, then  
120 this will delay the transmission of the L2\_Frame PDU by the  
round trip time (RTT) of the L2\_ARQ layer. The round trip  
time RTT of a layer is basically the time that passes between  
the sending of a data unit of that layer by a sending peer,  
and the receipt by the sending peer of the acknowledgment  
125 message that confirms that the given data unit was received  
at the other end by the receiving peer. The L2\_ARQ RTT is  
typically much longer than the L2\_ARQ Transmission delay.

130 As already mentioned, this delay can cause significant  
problems in higher layers.

135 Another problem can occur in systems where the L2\_ARQ peer  
uses window-based flow control. Window-based flow control is  
well-known in the art and basically means that the flow  
control is accomplished in accordance with a defined number  
140 of consecutive octets or bits that is referred to as a send  
window, where the allowed number of unacknowledged data units  
is limited to said send window. In other words, flow control  
is such that in a given series of data units to be sent, a  
certain number of data units following a given data unit may  
be sent out, even though the safe receipt of said given data  
unit has not yet been acknowledged, but this number of  
unacknowledged data units is limited to the send window. As  
already mentioned, this concept is well-known in the art, see

145 e.g. TCP/IP Illustrated, Vol. 1, The Protocols, by W. Richard Stevens, Addison-Wesley Longman, Inc. 1994. A further explanation is therefore not necessary.

150 In an L2\_ARQ peer that uses window-based flow control, the sender cannot send any new L2\_ARQ PDUs when the send buffer is exhausted with back-logged copies of L2\_ARQ PDUs that have already been sent but not acknowledged by the receiving L2\_ARQ peer. This will briefly be explained in connection with Fig. 9. This figure shows a consecutive series of PDUs 155 to be sent, fourteen in this example. According to window-based flow control, the left end (PDU 4) of the send window SW, which is shown as comprising the PDUs 4 to 10, moves in accordance with the PDUs that were sent and acknowledged. In the example of Fig. 9, PDUs 1 to 3 have been sent and 160 acknowledged, so that PDU 4 constitutes the left end of the send window. For the purpose of the present explanation it will be assumed that the length of the send window is constant.

165 The send window itself may be generally seen as having two parts, namely older PDUs that have been sent but not acknowledged (4 to 6) and the remaining PDUs in the send window SW, which in accordance with flow control are allowed to be sent because they are in the send window, but which 170 have not yet been sent (7 to 10).

175 A stall of the send window may occur in the following situation. As long as the oldest PDU (4 in the example) of the send window has not been sent correctly, it can not be acknowledged. As a consequence, if no acknowledgment for the oldest PDU is received, the left end of the send window SW will not move to the right. As long as there are PDUs in the send window that have not yet been sent, this basically does not cause problems, as a sending of PDUs continues. But if 180 all of the PDUs in the send window have been sent, then the

185 further transmission of PDUs is completely blocked as long as the oldest PDU is not acknowledged, i.e. the send window is stalled because it can not move to the right. As a consequence, the above described delay caused by L2\_ARQ retransmissions in the order of the round trip time may stall the send window and lead to a decreased throughput.

190 It is the object of the present invention to solve these problems and provide a communication device and method of the aforementioned kind that can reduce the delay caused by the L2\_ARQ layer retransmissions.

195 This object is solved by the devices and methods described in the independent claims.

200 195 According to the present invention, when having implementations of first protocol that specifies different reliability levels for sending PDUs of a second protocol, where the second protocol specifies segmentation of PDUs of a third, higher layer protocol, a capability is introduced for setting the reliability level of second protocol (L2\_ARQ) PDUs differently for second protocol PDUs belonging to a defined data structure containing such second protocol (L2\_ARQ) data units.

205 210 In the following, the terminology used in the introduction will be retained, and the above description is herewith incorporated into the description of the invention. In this way, the present invention can be used in the context of any mechanism for setting the reliability level, e.g. those already mentioned, i.e. transmission power, forward error correction, spreading factor, interleaving depth, modulation or antenna diversity etc., be it alone or in any desired combination.

215

According to a preferred embodiment, the defined data structure containing second protocol PDUs is one third protocol PDU that was segmented into second protocol PDUs, i.e. one L2\_Frame or L3 PDU in the above terminology. In this case, the present invention provides the capability of setting the L1 reliability level differently for L2\_ARQ PDUs with respect to their position in one L2\_Frame (or L3) PDU. In other words, the data units of the L2\_ARQ protocol that belong to one L2\_Frame PDU can have their reliability level set in dependence on specific properties relating to the fact that the L2\_ARQ PDUs are in one L2\_Frame PDU and relating to the relationship between these L2\_ARQ PDUs with respect to one another.

In this embodiment, the data units of the second protocol that belong to one data unit of a third protocol (referred to as L2\_Frame or L3 above) are identified, and the data units of the second protocol that belong together in such a way are then classified into at least two different categories, and finally the capability is provided of setting the reliability level for these data units of the second protocol differently for different categories.

According to a preferred version of this embodiment, it is possible to solve the above problem described in connection with Fig. 3, namely if two categories are defined, where the first relates to the L2\_ARQ data units belonging to the front part of a L2\_Frame or L3 data unit, and a second category is defined that relates to the L2\_ARQ data units that come towards the end, and it is possible to increase the reliability level (e.g. increased sending power or improved forward error correction) of the data units that come towards the end, the detrimental effect resulting from the situation described in connection with Fig. 3 can be avoided, because the increased level of reliability for such L2\_ARQ data unit such as b (see Fig. 3b), avoid the retransmission of such

255 L2\_ARQ data units, so that the delay caused by the retransmission of L2\_ARQ PDUs is preferably restricted to the actual L2\_ARQ transmission delay, and not determined by the round trip time.

260 According to another preferred embodiment, the defined data structure is not one PDU of the protocol that lies immediately above the L2\_ARQ protocol, but is one PDU of protocol that lies higher, e.g. referred to as L4 in Fig. 2. Preferably, as in the previous embodiment, the reliability level of L2\_ARQ PDUs that are associated with the end of the L4 PDU is set higher than the level of the preceding L2\_ARQ PDUs. This embodiment is especially advantageous in the event 265 that the L4 PDU is fragmented into more than one L3 PDU. An example of this is the so-called IP fragmentation of TCP packets. Then it is e.g. possible to set the reliability level of those L2\_ARQ PDUs that belong to the fragments towards the end of the L4 PDU higher than for the PDUs 270 belonging to the first fragments.

275 According to another preferred embodiment, the defined data structure containing L2\_ARQ data units is the send window used for window-based flow control. Then, the problem of stalled windows in window-based flow control may be solved, namely by differentiating between L2\_ARQ PDUs that are at the beginning of the send window (older PDUs) and those that are towards the end (younger PDUs), where the retransmission of older PDUs (e.g. PDU 4 in Fig. 9) is done with a higher 280 reliability level than for the first transmission of the same PDU and/or than for younger PDUs. Preferably the degree of increase of the reliability level is a function of the age (i.e. the older the higher) and/or a function of how often the PDU has been transmitted (i.e. each repeated 285 retransmission receives a higher reliability level than the previous retransmission or the first transmission).

Also, with the help of another preferred embodiment, it is possible to discriminate between different parts of an L3, L2\_Frame, or L4 PDU at the L1 protocol layer, and to treat those discriminated parts differently. It becomes possible to set the reliability level of certain parts that are more sensitive to delay higher than the reliability level of other parts. For example, the IP header of an IP packet (L3 PDU) could be protected more (transmitted at a higher L1 reliability level) than the payload. This decreases the average delay for transmitting the IP header (less L2\_ARQ retransmissions) and allows the IP router to make the routing decision as soon as possible.

300

The inventive concept, which may be referred to as providing the capability of unequal error protection for different parts of a defined data structure, presents the following advantages:

305

- low end-to-end third protocol (L2\_FRAME/L3) PDU transfer delay,
- low end-to-end third protocol (L2\_FRAME/L3) PDU delay jitter,
- efficient bandwidth utilization,
- less buffer space for storing the L2\_ARQ PDUs thus reducing the overall system cost, and
- if the scheme is implemented at every possible protocol layer, the savings due to less buffer space requirements may be very high and the overall quality of service perceived by users improves.

A very important advantage of the present invention is that it does not require any modifications of the relevant

325 protocols themselves, i.e. it does not affect any standard.  
It only requires changes to the protocol implementations.

330 Other features and advantages of the present invention will become more apparent from the following detailed description of preferred embodiments, which make reference to the figures, in which

Fig. 1 shows an explanatory diagram of the present invention;

335 Fig. 2 shows a generic protocol stack;

Fig. 3 explain certain problems that can occur in connection with the protocol arrangement shown in Fig. 2;

340 Fig. 4 shows an embodiment of the present invention, Fig. 5 shows a transmission plane of specific protocols;

345 Fig. 6 shows the segmentation and transmission of an LLC frame;

Fig. 7 explains the impact of block errors on the LLC Frame transfer delay;

350 Fig. 8 shows the impact of the RLC send window and block errors on the LLC Frame transfer; and

355 Fig. 9 explains the problem of a stalled send window in window-based flow control.

Fig. 1 shows an embodiment of the present invention, in which the defined data structure containing L2\_ARQ PDUs is a data unit of the L3 protocol. This figure will now be explained.

The left side of the figure shows a flow diagram, whereas the upper right part of the figure contains representations that serve to better understand steps S1 and S2.

365

In accordance with the present embodiment, it is assumed that a communication device implements a first and second communication protocol, e.g. the previously mentioned protocols L1 and L2\_ARQ, respectively. The first protocol provides rules for controlling the transmission of data units of the second protocol across a given physical connection, and this first protocol provides at least two different reliability levels for the transmission of data units of the second protocol. Moreover, the second protocol provides rules for the segmentation of data units of a third protocol (e.g. the above mentioned L2\_Frame or L3) into data units of the second protocol, and additionally the second protocol provides for the retransmission of data units of the second protocol under predetermined conditions. In other words, the second protocol has the above mentioned automatic repeat request feature ARQ.

On the right hand side of Fig. 1, the segmentation of a given PDU of a third protocol into PDUs of the second protocol is shown. In step S1, the PDUs of the second protocol that belong to one PDU of the third protocol are identified. This can be done in any suitable manner, e.g. by having the implementation of the second protocol determine the start and end of a third protocol PDU (e.g. the start flag and end flag) when performing the segmentation, and then communicating this information to the implementation of the first protocol, or the implementation of the first protocol is done in such a way that it may identify said starting and

395 end point of the data unit of the third protocol by parsing  
the data units of the third protocol directly.

400 It may be noted that this is an important distinction to  
known systems, in which lower layer implementations handle  
upper layer data transparently, i.e. are oblivious to how the  
data is structured in the upper layer context.

405 Then, in step S2, the PDUs of the second protocol are  
classified into predetermined categories. This is again  
exemplified on the right hand side of Fig. 1, by the depicted  
arrows. It should be noted that the depiction is to be  
understood in an abstract way, and not as meaning that the  
order in which the data units of the second protocol are  
arranged, in terms of transmission, is changed. More  
specifically, the order in which the PDUs of the second  
410 protocol are arranged is not changed by the classifying into  
categories.

415 Then, in step S3 there is a branching that depends on one or  
more predetermined conditions. No specific condition is  
given, as the present invention consists not in a specific  
condition, but much rather in the general concept of  
providing the capability that the reliability level for the  
PDUs of the second protocol is set in accordance with the  
categories into which the PDUs were classified in step S2.  
420 This can be seen in step S4 and S5. More specifically, in  
step S4 the reliability level for PDUs in one category is set  
differently than the reliability level in another category.  
In contrast thereto, in step S5, the reliability level is set  
independently of category, e.g. as it is done in known  
425 physical layer implementations, which were referred to as L1  
above.

Therefore, the steps S3, S4 and S5 express the capability  
that the present invention provides, namely the capability of

430 setting the reliability level for PDUs of the second protocol that belong to one PDU of the third protocol differently depending on rules of classification that specify certain categories.

435 Fig. 4 explains a preferred version of the above embodiment that solves the above described problem of an unbounded delay per third protocol PDU (e.g. L2\_FRAME or L3 PDU). The same expressions as already used in connection with Figures 2 and 3 will be used again for easier understanding.

440 Fig. 4 shows one L2\_FRAME PDU that has been segmented into a given number of L2\_ARQ PDUs. Naturally, an L3 PDU could equally well be considered. In this embodiment, two categories for classification are provided. The first 445 category is referred to as the General Protection Window GPW, and the second category is referred to as the Special Protection Window SPW.

450 The Special Protection Window SPW is defined as a consecutive sequence - in terms of the order of transmission - of L2\_ARQ PDUs of one L2\_FRAME PDU including the last (potentially retransmitted) L2\_ARQ PDU that will be transmitted for that L2\_FRAME PDU. It should be noted that the SPW can also be zero.

455 The General Protection Window GPW is defined as a consecutive sequence - in terms of the order of transmission - of L2\_ARQ PDUs of one L2\_FRAME PDU including the first L2\_ARQ PDU that will be transmitted for that L2\_FRAME PDU. The GPW may also 460 be zero.

465 The size of the SPW is initialized to a certain value, e.g. to comprise as many L2\_ARQ PDUs as can be transmitted during the L2\_ARQ RTT (in other words the quotient of the RTT and the L2\_ARQ transmission delay). The size of the GPW is

initialized to complement the initial SPW, i.e. the sum of the SPW and GPW corresponds to the complete L2\_FRAME PDU. The size of the GPW may be fixed to the initial value. In that case every retransmission of an L2\_ARQ PDU from the GPW 470 increases the SPW by one. Alternatively, the size of the GPW may increase for every retransmission of an L2\_ARQ PDU of GPW up to a certain maximum value. After that maximum value has been reached, the size of the GPW remains constant and instead every retransmission of an L2\_ARQ PDU of GPW 475 increases SPW by one.

A History Window HW is also defined, which is a consecutive sequence of L2\_ARQ PDUs including the last transmitted L2\_ARQ PDU at a given point in time during the transmission of 480 L2\_ARQ data units that belong to the one L2\_FRAME data unit.

The L1 protocol reliability level of each L2\_ARQ PDU in the GPW is decided by the general protection adaptation mechanism for that protocol. The term general protection adaptation 485 mechanism refers to the mechanism for setting the reliability level that is already provided in said protocol. This mechanism decides on the reliability level for each L2\_ARQ PDU independent of which position within the respective L2\_FRAME PDU (or L3 PDU) that L2\_ARQ PDU holds. As already 490 mentioned, this mechanism can be given in a variety of ways, depending on the specific L1 protocol, and can e.g. be a mechanism that sets the reliability level in dependence on the quality of the connection over which the data units are being sent.

495 In accordance with the invention a special protection adaptation mechanism is defined for the SPW, and the reliability level of each L2\_ARQ PDU in the SPW is decided by this special protection adaptation mechanism. The special 500 protection adaptation mechanism serves to minimize the probability that an L2\_ARQ PDU in the SPW has to be

retransmitted, while balancing this against minimizing the required transmission resources (e.g. transmission power). If it is deemed necessary in accordance with a given criterion 505 (see step S3 in Fig. 1), then this can be achieved by raising the L1 reliability (e.g. raising the transmission power and/or improving the forward error control) level for the L2\_ARQ PDUs in the SPW. Preferably the criterion for raising the L1 reliability in the SPW depends on the number 510 of L2\_ARQ PDUs in the GPW that need to be retransmitted. For example, if the number of L2\_ARQ PDUs from the GPW that needs to be retransmitted lies below a predetermined threshold, then the reliability level in the SPW is adjusted by the same mechanism as in the GPW (see step S5 in Fig. 1), and 515 otherwise the reliability level in the SPW is raised with respect to that of the GPW (see step S4 in Fig. 1). In other words, the special protection adaptation mechanism in this case simply consists in raising the reliability level by a predetermined factor with respect to the general protection 520 adaptation mechanism. An alternative mechanism could consist in measuring the number of retransmissions that take place until the history window HW reaches a predetermined value, and then to decide on the changing of the reliability in the special protection window on the basis of this measured 525 number. Another alternative may consist in simply setting the reliability level of a given percentage of the L2\_ARQ PDUs at the end of each L2\_FRAME or L3 PDU higher, regardless of the number of retransmissions or any other condition. Naturally, more complicated mechanisms containing further dependencies 530 on specifically defined conditions are possible, but this lies outside of the scope of the present invention.

Consequently, it may be noted that the present invention is not restricted to any specific special protection adaptation 535 mechanism, as such a mechanism may be selected in accordance with the requirements and preferences associated with a specific situation and protocol or protocols. Much rather,

the above embodiment clearly expresses the basic concept of the invention, according to which the capability is provided  
540 for setting the reliability level in accordance with categories that are determined by classifying rules. In the above embodiment, these classifying rules relate to the location of a given L2\_ARQ PDU with respect to the beginning and end of an L2\_FRAME (or L3 or L4) PDU.

545 In this way, the embodiment provides a means for potentially applying special protection to L2\_ARQ PDUs that lie at the end of the sequence belonging to one L2\_FRAME PDU, thereby eliminating the problem described in connection with Fig. 3.

550 In the previous embodiments, the defined data structure was one PDU of the protocol that lies immediately above the L2\_ARQ protocol, but the defined structure may, equally well be one PDU of a protocol that lies higher, e.g. a protocol  
555 referred to as L4 in Fig. 2. Accordingly the definition of the special protection window SPW and general protection window GPW is based upon the L4 PDU instead of the L2\_FRAME or L3 PDU. Preferably, as in the previous embodiments, the reliability level of L2\_ARQ PDUs that are associated with the  
560 end of the L4 PDU is set higher than the level of the preceding L2\_ARQ PDUs. This is especially advantageous in the event that the L4 PDU is fragmented into more than one L3 PDU. An example of this is the so-called IP fragmentation of L4 PDUs. Then it is e.g. possible to set higher the  
565 reliability level of those L2\_ARQ PDUs that belong to the fragments towards the end of the L4 PDU.

570 In the following, another embodiment of the present invention will be described, in which window-based flow control is employed, and the defined data structure containing L2\_ARQ PDUs is the send window. This embodiment specifically addresses the above mentioned problem of a stalled window when using window-based flow control. The following

575 description is similar to that of the above embodiment,  
except that the data structure inside of which the PDUs are  
differentiated is the send window and not a higher layer PDU.

580 In this embodiment, the classification is done with respect  
to position in the send window. The solution to the stalled  
send window problem consists in enabling special protection  
for the retransmission of older L2\_ARQ data units in the send  
window of the sending L2\_ARQ peer, namely the capability is  
provided that the L1 reliability level is set higher for PDUs  
that need to be retransmitted and that lie at the beginning  
585 of the send window SW.

590 In other words, the problem of stalled windows in window-  
based flow control may be solved by differentiating between  
L2\_ARQ PDUs that are at the beginning of the send window  
(older PDUs) and those that are towards the end (younger  
PDUs), where the retransmission of older PDUs (e.g. PDU 4 in  
Fig. 9) is done with a higher reliability level than for the  
first transmission of the same PDU and/or than for younger  
PDUs. In other words, for a given PDU (e.g. PDU 4 in Fig. 9),  
595 the reliability level of the first retransmission is set  
higher than the reliability level for the first transmission,  
the reliability level for the second retransmission is set  
higher than for the first retransmission, etc. However, it is  
equally well possible that the reliability level is only  
600 raised for the first retransmission with respect to the first  
transmission, and then remains constant for all following  
retransmissions. Preferably the degree of increase of the  
reliability level is a function of the age, i.e. the older  
the PDU, the higher the reliability level increase. In other  
605 words, in the context of the example shown in Fig. 9, the  
increase in reliability level for PDU 4 would be higher than  
for PDU 5.

610 An alternative to this can consist in making the degree of  
increase (be it only between the first transmission and the  
first retransmission, or between consecutive retransmissions)  
dependent on the number of PDUs in the send window that have  
not yet been sent (right side in Fig. 9). It is clear that  
this mechanism for adjusting the degree of increasing the  
615 reliability level can be combined with the above mechanisms  
in any desirable way.

620 In the above embodiment, the rules for classifying the L2\_ARQ  
PDUs not only relate to the position in the predetermined  
data structure (i.e. the send window), but also to the amount  
of retransmissions of the PDU.

625 As was the case with the embodiment in which the defined data  
structure was a higher layer data unit, there is no  
restriction to a specific protection mechanism.

630 It may be noted that in the case of the above embodiment, in  
which the defined data structure containing L2\_ARQ PDUs is  
the send window, the higher layer data units may again be  
handled transparently, i.e. as a continuous bit stream.  
However, it is equally well possible to combine the above  
embodiments in one system, i.e. to provide a system in which  
the reliability level may be set both with respect to  
position in higher layer data units as well as with respect  
635 to position in the send window. This leads to a more  
complicated system, but enhances performance.

640 Now another embodiment of the present invention will be  
described, in which again the defined data structure is an L3  
or L2\_FRAME PDU. However, now the classification rules are  
not associated with the beginning and end of the L2\_FRAME or  
L3 PDU, much rather they are related to different ranges of  
consecutive octets or bits of the data unit of the L2\_FRAME  
or L3 protocol, where the ranges each correspond to a

645 consecutive number, in terms of order of transmission, of  
L2\_ARQ PDUs.

650 Preferably, two categories are specified, where a first  
category is associated with the header of the L2\_FRAME or L3  
PDU, and the second category is associated with the payload  
thereof.

This embodiment may also be combined with one or all of the  
previous embodiments.

655 Now, in order to provide a better understanding of the  
concepts and embodiments discussed above, a detailed example  
will be described in terms of specific protocols and GPRS.  
However, this example should not be seen as restrictive, as  
660 the present invention is applicable to any communication  
standard and protocol set that provide the features described  
in the claims.

665 For this specific example, SNDCP (Subnetwork Dependent  
Control Protocol) or network correspond to L3, LLC (Logical  
Link Control) corresponds to L2\_FRAME, RLC/MAC (Radio Link  
Control/Medium Access Control; specified in standard  
GSM04.60) corresponds to L2\_ARQ, and PLL/RFL (Physical Link  
Layer/ Radio Frequency Layer) corresponds to L1.

670 Fig. 5 gives a background overview of GPRS. It shows the GPRS  
transmission plane up to the network layer. Radio  
communication between the GPRS network and the mobile station  
MS covers physical and data link functionality. Between the  
675 BSS (Base Station Subsystem) and the MS, the data link layer  
has been separated into two distinct sub-layers: the LLC  
layer and the RLC/MAC sub layers. The variable length PDUs  
transferred between two LLC entities are called LLC frames.  
The data transfer between RLC entities occur in variable size  
680 RLC blocks.

For efficient transmission on the radio interface, an LLC PDU is segmented into smaller size RLC blocks as depicted in Fig. 6. This allows retransmissions to be performed at the RLC 685 block level. The retransmissions of the erroneous RLC blocks are controlled through a selective ARQ mechanism. RLC blocks are transmitted within a window size of  $k$  blocks and the receiving side periodically sends temporary ACK/NACK (acknowledged / not acknowledged) messages. Every ACK/NACK 690 message acknowledges all correctly received RLC blocks up to an indicated block number thus moving the beginning of the send window. Additionally, a bitmap is used to selectively request erroneously received RLC blocks. The acknowledgment of outstanding data results in further sliding of the send 695 window. When all the RLC blocks corresponding to an LLC PDU are successfully received, the LLC PDU is delivered to the higher layer.

An RLC connection is established between two peer entities 700 for the transmission of RLC blocks. Each RLC end-point has a receiver that receives RLC blocks and a transmitter that transmits RLC blocks. Each end-point's transmitter has a send window, while each end-point's receiver has a receive window. The block transmission between two peer RLC entities is 705 controlled through these two windows.

If  $V(S)$  denotes the sequence number of the next-in-sequence RLC block to be transmitted,  $V(A)$  denotes the block sequence number of the oldest data block that has not been positively 710 acknowledged by its peer, and  $n$  and  $k$  denote the block number sequence length and the window size, respectively, then the send window may be stalled (no fresh block transmission) when  $V(S) = [V(A) + k] \bmod n$ .

715 Two approaches are commonly used in order to transmit the RLC blocks on the radio interface:

- RLC blocks belonging to an LLC PDU are transmitted with the same degree of protection (coding rate etc.), and

720

-different blocks in a flow block can use different modulation and coding rates in order to adapt to the radio channel conditions (Link Adaptation LA).

725 The Link Adaptation LA was referred to generally as the L1 general protection adaptation above.

Now the underlying problem will be described in terms of GPRS. The end-to-end delay for a packet (e.g. LLC frame) is 730 an important parameter. The LLC frames having some blocks retransmitted may be additionally delayed waiting for the retransmissions. It is noted that if the blocks transmitted in the beginning and the middle of an LLC frame are received with errors, NACK can be received during the remaining block 735 transmission of this LLC frame and the erroneous block(s) can be retransmitted just after or before the last block transmission. On the other hand, if the last blocks of an LLC frame have to be retransmitted, these may cause supplementary delay due to waiting for ACK/NACK even after the transmission 740 of the very last block. This further delays the delivery of the packet to the LLC layer. The problem then is how this kind of supplementary delay can be minimized.

745 The send window is stalled when  $V(S) = [V(A) + k] \bmod n$ , where  $V(A)$  refers to the oldest RLC data block that has not been positively acknowledged. It is noted that if all the blocks within a block flow are transmitted with the same degree of protection (or adapted only to the radio channel conditions), the chances are higher that the send window will then be 750 stalled. When the send window is stalled, no fresh RLC block can be transmitted. The problem is then how to avoid the send window from being stalled.

755 In accordance with the present invention, it is possible to protect the different RLC blocks belonging to an LLC frame or within a RLC block flow differently. The concept will be explained with the help of two examples embodying the present invention. In the first case blocks containing data from the end of an LLC frame will be transmitted with more protection, 760 and in the second case blocks causing the send window to be stalled are transmitted with more protection compared to the other blocks. It should be noted that "more protection" means more compared to the protection determined by the LA algorithm.

765

In the first case, i.e. more protection for blocks at the end of an LLC frame, the present invention suggests to transmit some of the blocks at the end of an LLC PDU with more protection (coding) than the rest of the blocks, thus 770 reducing the probability of error for these blocks. This helps reduce the delay to deliver a packet to the LLC layer. The present invention can be generalized to other layers as well, e.g. the whole last LLC frame (when there are several LLC frames per network-PDU) in a series can be transmitted 775 with more protection.

This will be explained by referring to the example illustrated in Fig. 7. The ACK/NACK period is considered to be equal to four block periods. In case (A), an erroneous 780 block at the beginning of the LLC frame was retransmitted immediately after the last block. In case (B), LLC frame delivery was delayed three block periods compared to case (A), because the last block went erroneous. In case (C), the last two blocks were transmitted with more coding and no 785 block went erroneous. It may be noted that one more block was transmitted due to coding overheads. It is apparent that even after counting coding overheads, the LLC frame was delivered much earlier in case (C) than in case (B).

790 In the second case, i.e. more protection for blocks causing send window stalling, it may be deduced from the window stall condition  $V(S)=[V(A)+k] \bmod n$  that the blocks at the beginning of a block flow (if received with errors) are more likely to stall the window than the blocks at the end of the 795 flow. This phenomenon is illustrated in Figure 8, part (A), with  $K=4$  and  $n=8$ . The ACK/NACK period is also considered to be equal to four block periods.

800 In part (B), the block 4 is received with errors and retransmitted immediately after the first ACK/NACK message. The whole frame is delivered in seven block periods. Since the error occurred towards the end of the frame (or block flow), there was no effect observed on the send window.

805 In case (C), block number 1 and 3 are received with errors. Since the block number 1 in the beginning of the flow went erroneous, the send window is stalled. The stall condition may persist if the block number 1 is again received with errors, thus increasing the frame transfer delay as depicted 810 in Fig. 8, part (C).

815 In part (D) of Fig. 8, block number 1 causing the stall condition is retransmitted with more protection, thus helping the send window to advance.

820 Since the blocks in the beginning of a flow are more likely to stall the window, they can be transmitted with more protection right from their first transmission, as illustrated in part (E).

820 Although the present invention was described above in terms of specific examples, this serves the purpose of conveying a better understanding to the skilled person, but is not intended to restrict the scope. Much rather, the scope is

825 defined by the appended claims, where reference signs are also included for better understanding and do not restrict the scope.

830

Claims

1. A communication device for data unit based communication,

835 comprising

implementations of a first and second communication protocol (L1, L2\_ARQ), where said first protocol (L1) provides rules for controlling the transmission of data units of said second protocol (L2\_ARQ) across a physical connection and provides at least two different reliability levels for the transmission of data units of said second protocol (L2\_ARQ), and said second protocol (L2\_ARQ) provides rules for the segmentation of data units of a third protocol (L2\_FRAME; L3) into data units of said second protocol (L2\_ARQ) and for the retransmission of data units of said second protocol (L2\_ARQ),

850 identifying means for identifying those data units of said second protocol (L2\_ARQ) that belong to a defined data structure (L2\_FRAME PDU; L3 PDU; L4 PDU; SW) containing data units of said second protocol (L2\_ARQ),

855 classifying means for classifying the data units of said second protocol (L2\_ARQ) that belong to said defined data structure (L2\_FRAME PDU; L3 PDU; L4 PDU; SW) into at least two different categories according to predetermined classification rules, and

860 reliability setting means for setting the reliability level of said first protocol (L1) for the transmission and retransmission of a given data unit of said second protocol (L2\_ARQ) to be transmitted, said reliability setting means being capable of setting said reliability level differently for the transmission and/or

865

retransmission of data units of said second protocol (L2\_ARQ) belonging to said defined data structure (L2\_FRAME PDU; L3 PDU; L4 PDU; SW) that were classified  
870 into different categories.

2. Communication device according to claim 1, characterized in that said reliability levels provided by said first protocol (L1) are distinguished by at least one of transmission power, forward error control, spreading factor, interleaving depth, modulation and antenna diversity.  
875
3. Communication device according to claim 1 or 2, characterized in that said defined data structure (L2\_FRAME PDU; L3 PDU; L4 PDU; SW) is a data unit of said third protocol (L2\_FRAME; L3) or of a protocol (L4) above said third protocol.  
880
4. Communication device according to claim 3, characterized in that a first and a second category (GPW, SPW) are specified, where said classification rules are such that said first category (GPW) comprises zero data units or a consecutive number of data units, in terms of order of transmission, of said second protocol (L2\_ARQ), including the first data unit of said second protocol (L2\_ARQ) belonging to one data unit of said third protocol (L2\_FRAME; L3), and said second category (SPW) comprises zero data units or a consecutive number of data units, in terms of order of transmission, of said second protocol (L2\_ARQ) including the last data unit of said second protocol (L2\_ARQ) belonging to said one data unit of said third protocol (L2\_FRAME; L3).  
885  
890  
895
5. Communication device according to claim 4, characterized in that said reliability setting means is arranged to set, if a predetermined condition is met, the  
900

905 reliability level of the data units of said second category (SPW) such that their transmission reliability across said physical connection is higher than the transmission reliability for the data units of said first category (GPW).

910 6. Communication device according to claim 5, characterized in that said predetermined condition is related to the number of data units of said first category (GPW) that need to be retransmitted.

915 7. Communication device according to claim 3, characterized in that said classification rules are related to different ranges of consecutive octets or bits of said one data unit of said third protocol (L2\_FRAME; L3), said ranges each corresponding to a consecutive number of data units, in terms of order of transmission, of 920 said second protocol (L2\_ARQ).

925 8. Communication device according to claim 7, characterized in that at least a first and a second category are specified, where said first category is associated with the header of said one data unit of the third protocol (L2\_FRAME; L3) and said second category is associated with the payload of said one data unit of the third protocol (L2\_FRAME; L3).

930 9. Communication device according to claim 8, characterized in that said reliability setting means is arranged to set the reliability level of the data units of said first category such that their transmission reliability across said physical connection is higher than the 935 transmission reliability for the data units of said second category.

10. Communication device according to claim 1 or 2,

characterized in that

940

said second protocol (L2\_ARQ) specifies window-based flow control according to which a defined number of consecutive octets or bits is used as a send window (SW) and the flow control is performed such that the allowed number of unacknowledged data units of said second protocol (L2\_ARQ) is limited to said send window,

945

said defined data structure (L2\_FRAME PDU; L3 PDU; L4 PDU; SW) is said send window (SW), and

950

said classification rules relate to the position in the send window (SW) and/or the number of retransmissions of a given data unit of said second protocol (L2\_ARQ).

955 11. Communication device according to claim 10, characterized

in that said reliability setting means is arranged to set the reliability level for successive retransmissions of a given data unit such that the transmission reliability across said physical connection is higher for a given retransmission of said given data unit than for the previous first transmission or retransmission of said given data unit.

965 12. A communication method for data unit based communication using implementations of a first and second communication protocol, where said first protocol (L1) provides rules for controlling the transmission of data units of said second protocol (L2\_ARQ) across a physical connection and provides at least two different reliability levels for the transmission of data units of said second protocol (L2\_ARQ), said second protocol (L2\_ARQ) provides rules for the segmentation of data units of a third protocol (L2-FRAME; L3) into data units

970

975       of said second protocol (L2\_ARQ) and for the  
      retransmission of data units of said second protocol  
      (L2\_ARQ),

      comprising the steps:

980       identifying (S1) those data units of said second  
      protocol (L2\_ARQ) that belong to a defined data  
      structure (L2\_FRAME PDU; L3 PDU; L4 PDU; SW) containing  
      data units of said second protocol (L2\_ARQ),

985       classifying (S2) the data units of said second protocol  
      (L2\_ARQ) that belong to said data structure (L2\_FRAME  
      PDU; L3 PDU; L4 PDU; SW) into at least two different  
      categories according to predetermined classification  
990       rules, and

995       providing the capability (S3, S4, S5) of setting said  
      reliability level for the transmission and/or  
      retransmission differently for data units of said second  
      protocol (L2\_ARQ) belonging to said data structure  
      (L2\_FRAME PDU; L3 PDU; L4 PDU; SW) that were classified  
      into different categories.

13. Communication method according to claim 12,  
1000 characterized

      in that said reliability levels provided by said first  
      protocol (L1) are distinguished by at least one of  
      transmission power, forward error control, spreading  
      factor, interleaving depth, modulation and antenna  
1005       diversity.

14. Communication method according to claim 12 or 13,  
      characterized in that said defined data structure  
      (L2\_FRAME PDU; L3 PDU; L4 PDU; SW) is a data unit of

1010       said third protocol (L2\_FRAME; L3) or of a protocol (L4) above said third protocol.

15. Communication method according to claim 14, characterized

1015       in that a first and a second category (GPW, SPW) are specified, where said classification rules are such that said first category (GPW) comprises zero data units or a consecutive number of data units, in terms of order of transmission, of said second protocol (L2\_ARQ),  
1020       including the first data unit of said second protocol (L2\_ARQ) belonging to one data unit of said third protocol (L2\_FRAME; L3), and said second category (SPW) comprises zero data units or a consecutive number of data units, in terms of order of transmission, of said  
1025       second protocol (L2\_ARQ) including the last data unit of said second protocol (L2\_ARQ) belonging to said one data unit of said third protocol (L2\_FRAME; L3).

16. Communication method according to claim 15, characterized

1030       in that said in the reliability setting step, if a predetermined condition is met, the reliability level of the data units of said second category (SPW) is set such that their transmission reliability across said physical  
1035       connection is higher than the transmission reliability for the data units of said first category (GPW).

17. Communication method according to claim 16, characterized

1040       in that said predetermined condition is related to the number of data units of said first category (GPW) that need to be retransmitted.

1045       18. Communication method according to claim 14, characterized

in that said classification rules are related to different ranges of consecutive octets or bits of said one data unit of said third protocol (L2\_FRAME; L3), said ranges each corresponding to a consecutive number 1050 of data units, in terms of order of transmission, of said second protocol (L2\_ARQ).

19. Communication method according to claim 18, characterized

1055 in that at least a first and a second category are specified, where said first category is associated with the header of said one data unit of the third protocol (L2\_FRAME; L3) and said second category is associated with the payload of said one data unit of the third 1060 protocol (L2\_FRAME; L3).

20. Communication method according to claim 19, characterized

1065 in that in said reliability setting step the reliability level of the data units of said first category is set such that their transmission reliability across said physical connection is higher than the transmission reliability for the data units of said second category.

1070 21. Communication method according to claim 12 or 13, characterized in that

1075 said second protocol (L2\_ARQ) specifies window-based flow control according to which a defined number of consecutive octets or bits is defined as a send window (SW) and the flow control is performed such that the allowed number of unacknowledged data units of said second protocol (L2\_ARQ) is limited to said send window,

1080 said defined data structure (L2\_FRAME PDU; L3 PDU; L4 PDU; SW) is said send window (SW), and

1085        said classification rules relate to the position in the send window (SW) and/or the number of retransmissions of a given data unit of said second protocol (L2\_ARQ).

22. Communication method according to claim 21, characterized

1090        in that the reliability level for successive retransmissions of a given data unit is set such that the transmission reliability across said physical connection is higher for a given retransmission of said given data unit than for the previous first transmission or retransmission of said given data unit.

1095

23. A communication device for data unit based communication, comprising

1100        implementations of a first and second communication protocol (L1, L2\_ARQ), where said first protocol (L1) provides rules for controlling the transmission of data units of said second protocol (L2\_ARQ) across a physical connection and provides at least two different reliability levels for the transmission of data units of said second protocol (L2\_ARQ), and said second protocol (L2\_ARQ) provides rules for the segmentation of data units of a third protocol (L2\_FRAME; L3) into data units of said second protocol (L2\_ARQ) and for the retransmission of data units of said second protocol (L2\_ARQ),

1110        classifying means for classifying the data units of said second protocol (L2\_ARQ) into at least a first and a second category, said classifying of a given data unit of said second protocol (L2\_ARQ) being done on the basis of information contained in the data unit of said third

protocol (L2\_FRAME; L3) of which said given data unit of said second protocol (L2\_ARQ) is a segment,

1120

1125

1130

reliability setting means for setting the reliability level of said first protocol (L1) for the transmission and retransmission of data units of said second protocol (L2\_ARQ) to be transmitted, said reliability setting means being capable of setting said reliability level differently for the transmission and/or retransmission of data units of said second protocol (L2\_ARQ) belonging to said first category than for the transmission and/or retransmission of data units of said second protocol (L2\_ARQ) belonging to said second category.

24. A communication device according to claim 23, characterized in that said classifying means is capable of reading one or more predetermined fields in the data units of said third protocol (L2\_FRAME; L3) to thereby classify the data units of said second protocol (L2\_ARQ) into which a data unit of said third protocol is segmented.

1140 25. A communication device according to claim 24, characterized in that said data units of said third protocol (L2\_FRAME; L3) comprise a header and a payload section, where the header contains a protocol identifying field and the payload section may contain one or more protocol identifying fields associated with data units of protocols that are of layers higher than said third protocol (L2\_FRAME; L3) that may be encapsulated in said data unit of said third protocol (L2\_FRAME; L3), and said predetermined fields that the classifying means may read comprise at least one of said protocol identifying field in said header and the one or more protocol identifying fields contained in said payload section.

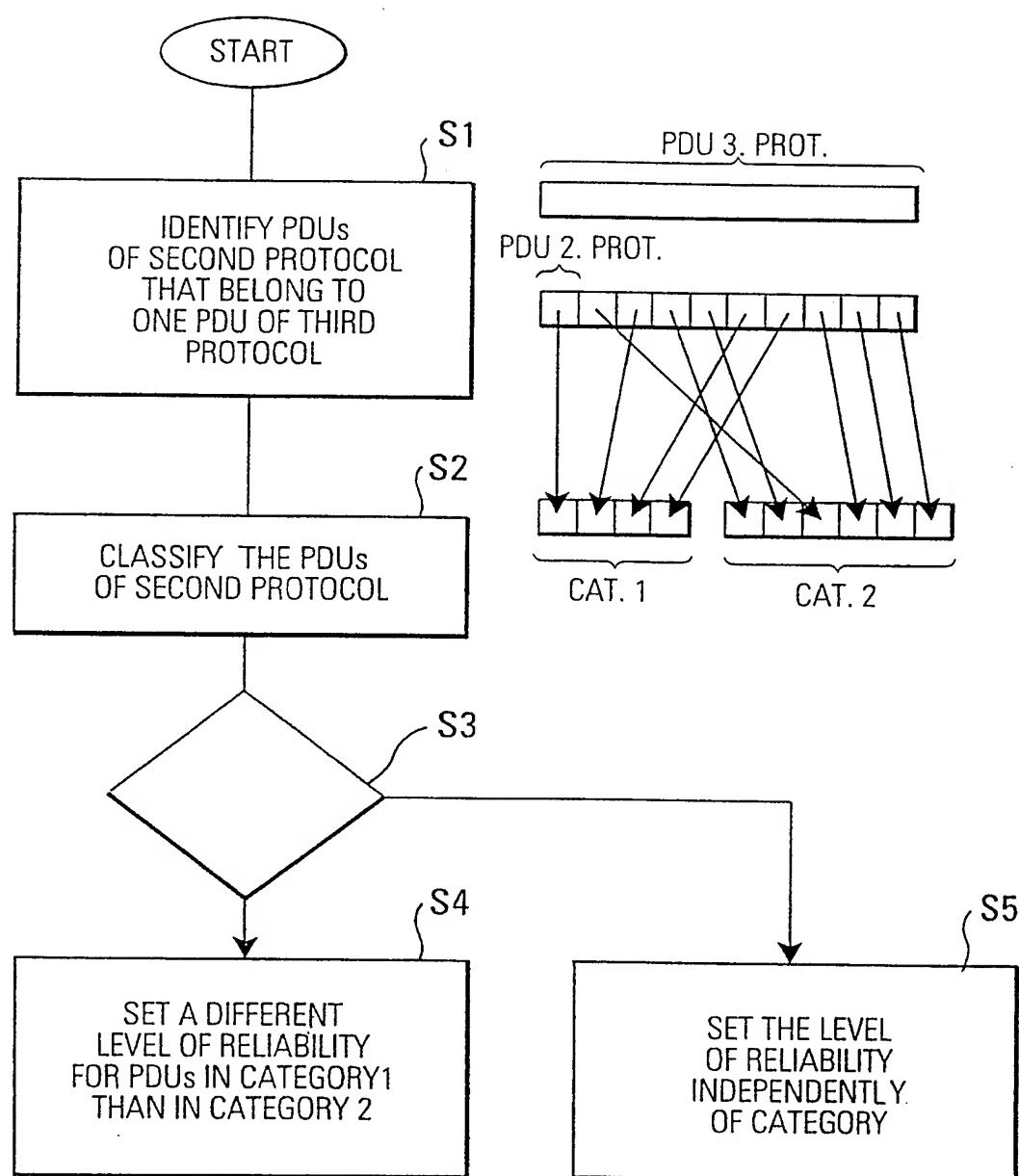
1155 26. A communication device according to claim 24 or 25,  
characterized in that said data units of said third  
protocol (L2\_FRAME; L3) comprise one or more quality of  
service fields that are associated with respective  
protocols, and said predetermined fields that the  
1160 classifying means may read comprise at least one of said  
quality of service fields.

27. A communication device according to one of claims 23 to  
26, characterized in that said first category contains  
1165 data units of said second protocol (L2\_ARQ) that are  
segments of data units of said third protocol (L2\_FRAME;  
L3) that encapsulate data units of a first higher layer  
protocol (TCP) that specifies retransmission of data  
units of said first higher layer protocol (TCP) under  
1170 predetermined conditions, and said second category  
contains data units of said second protocol (L2\_ARQ)  
that are segments of data units of said third protocol  
(L2\_FRAME; L3) that encapsulate data units of a second  
higher layer protocol (UDP) that does not specify  
1175 retransmission of data units of said second higher layer  
protocol (UDP).

28. A communication device according to claim 27,  
characterized in that reliability setting means is  
1180 arranged to set the reliability level of said data units  
of said second protocol (L2\_ARQ) in said second category  
higher than the reliability level (L2\_ARQ) of said data  
units of said second protocol (L2\_ARQ) in said first  
category.

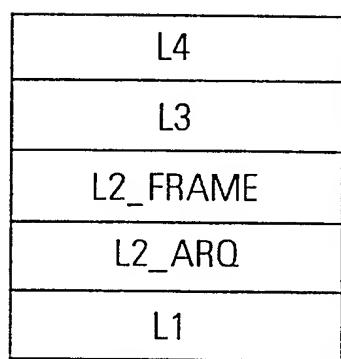
1185

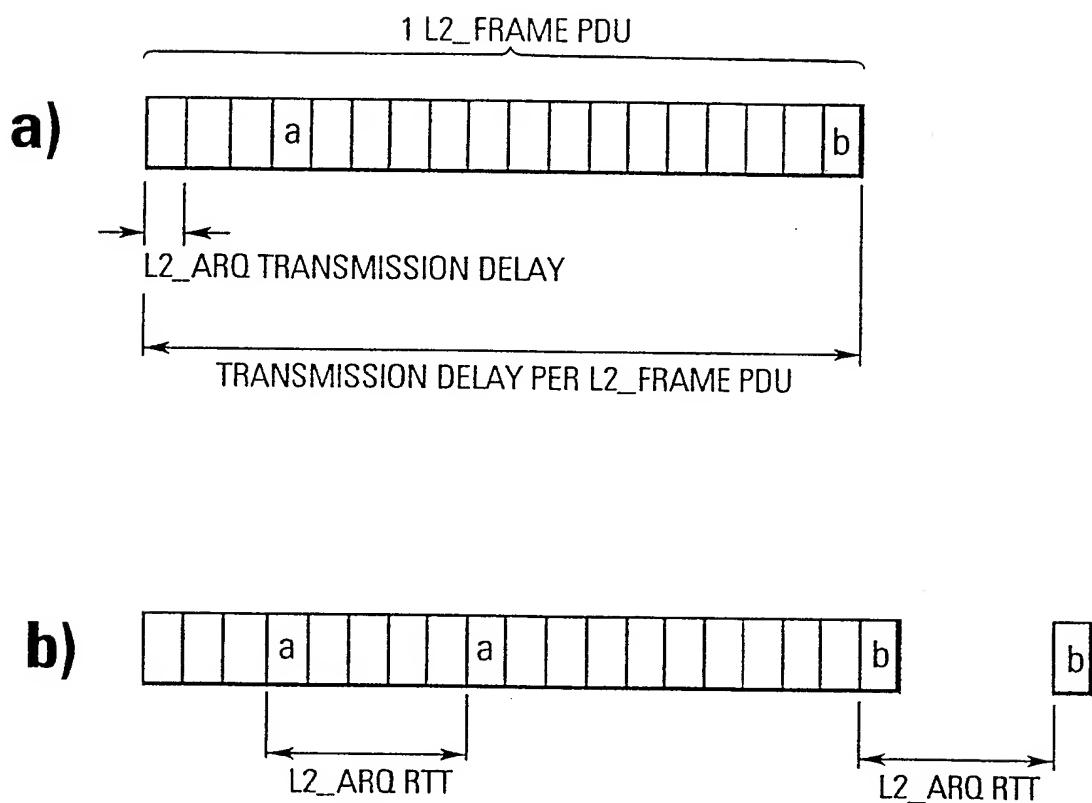
FIG.1



2/9

## FIG.2



**FIG.3**

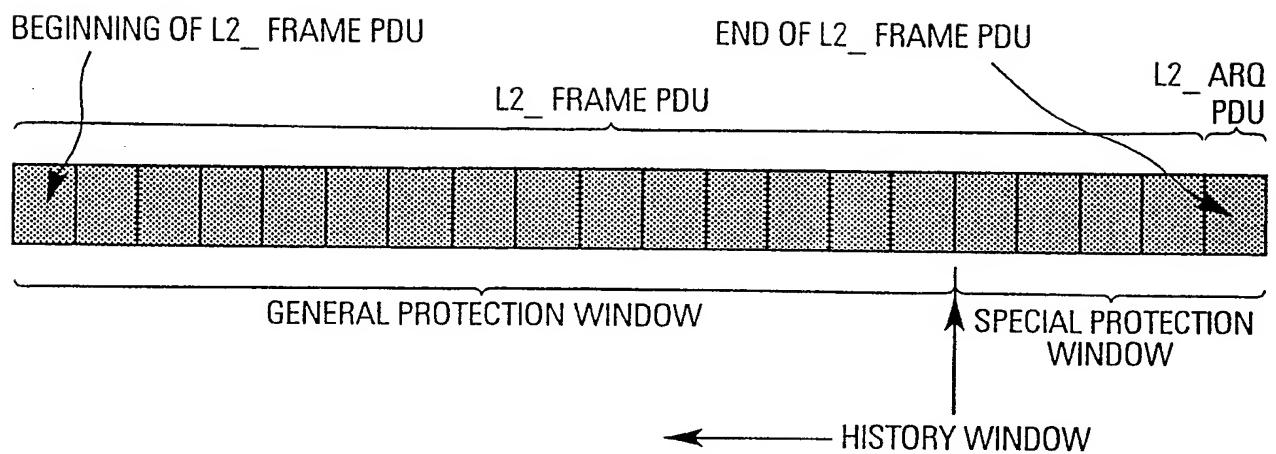
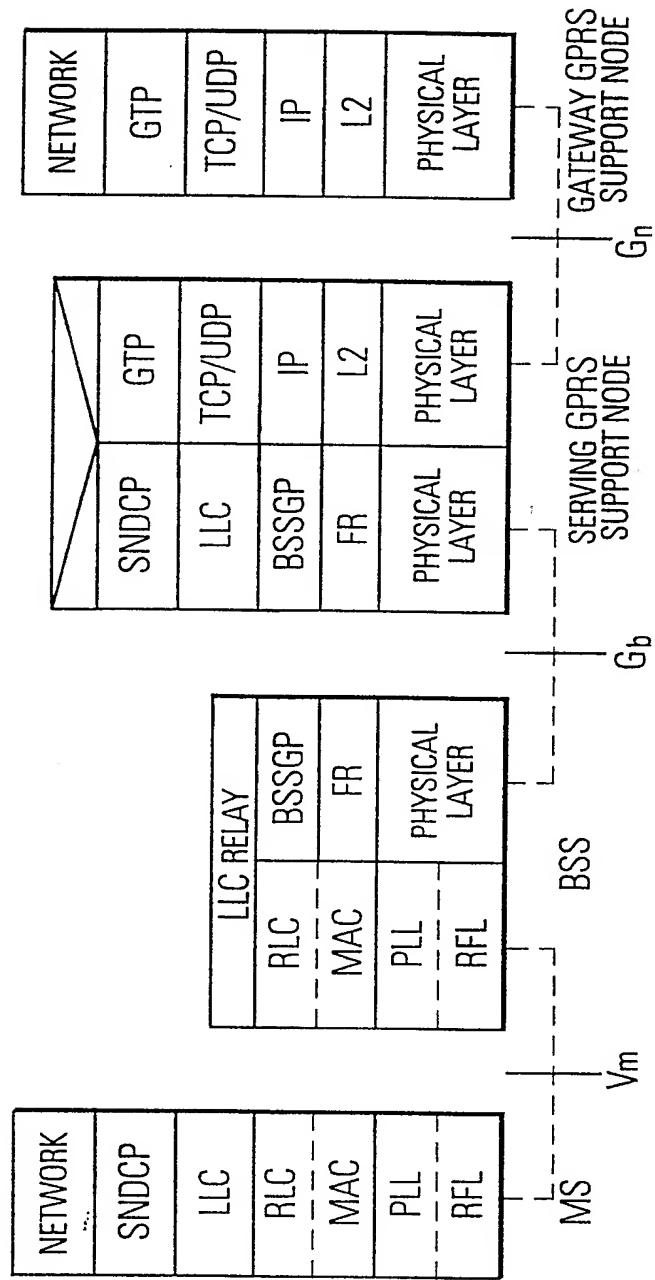
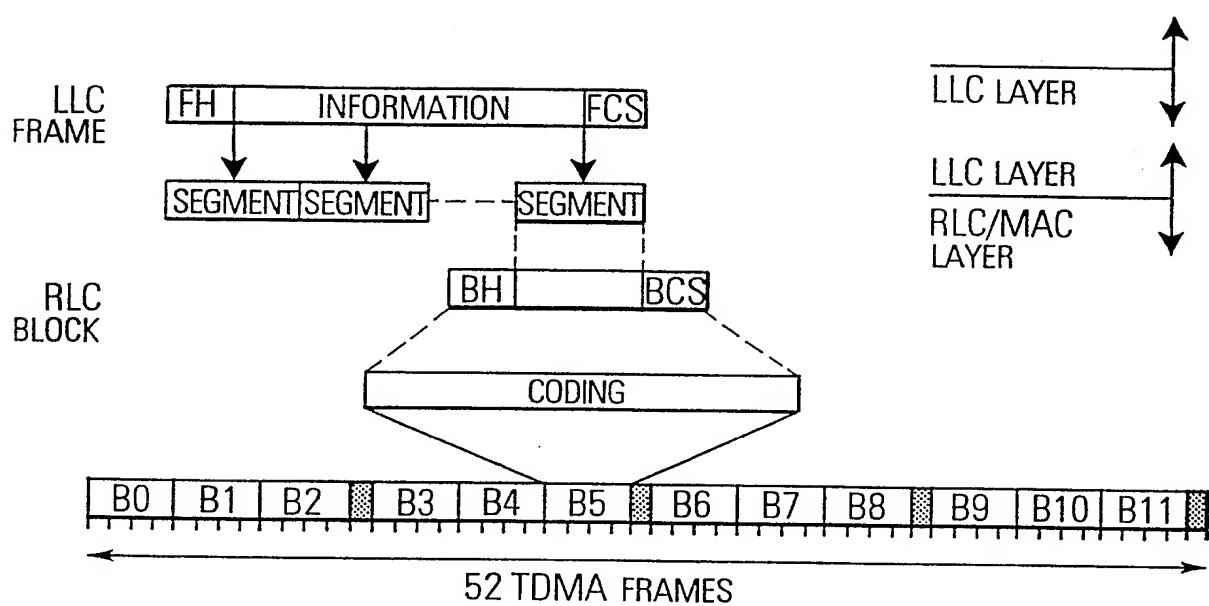
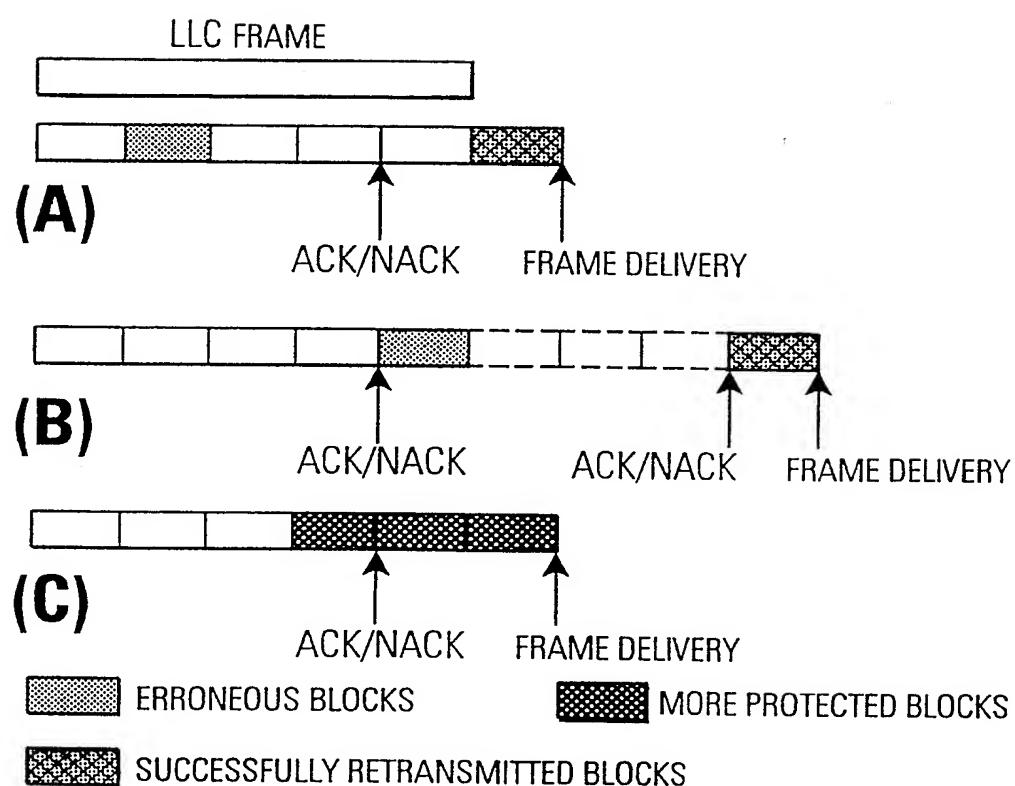
**FIG.4**

FIG.5



**FIG.6**

**FIG.7**

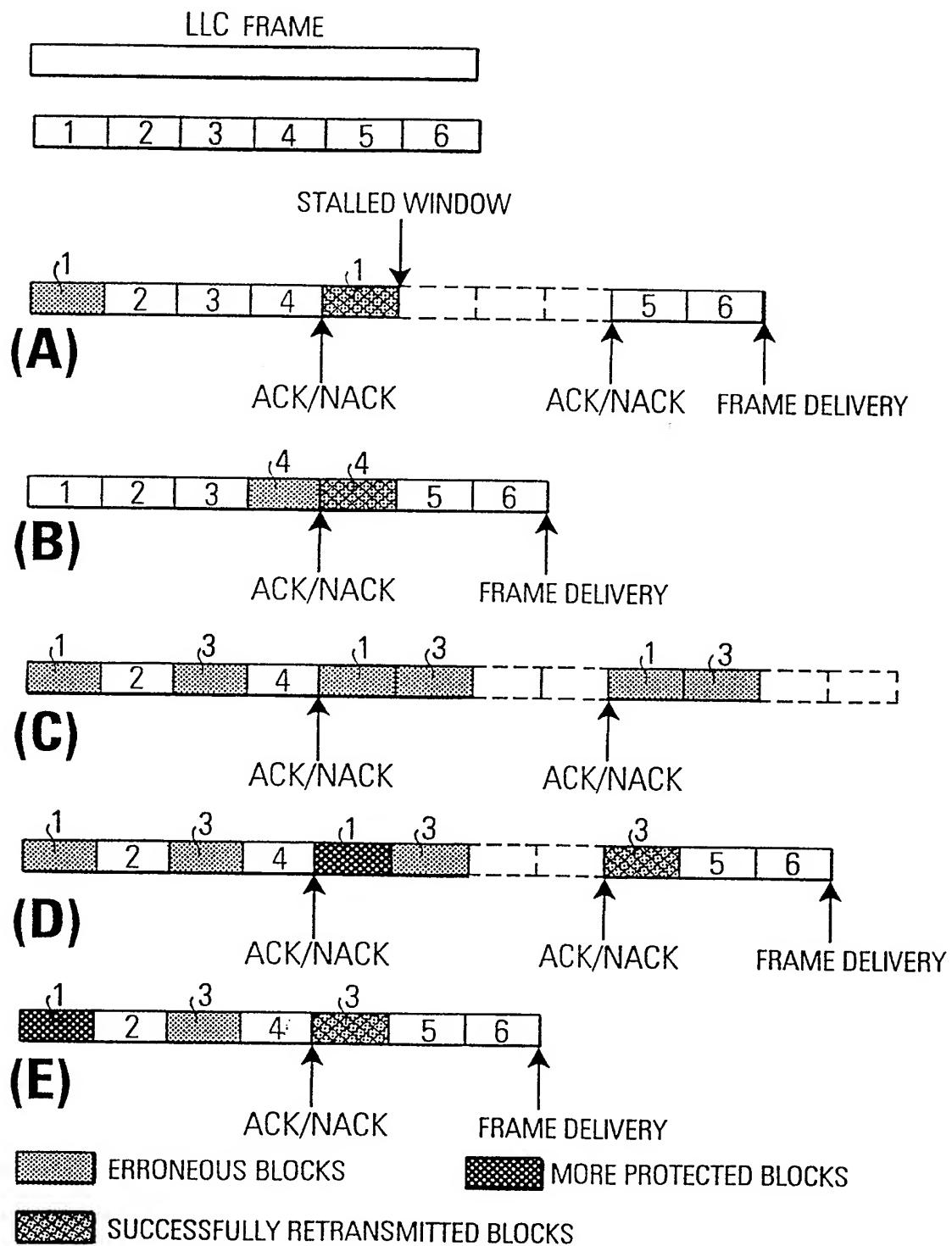
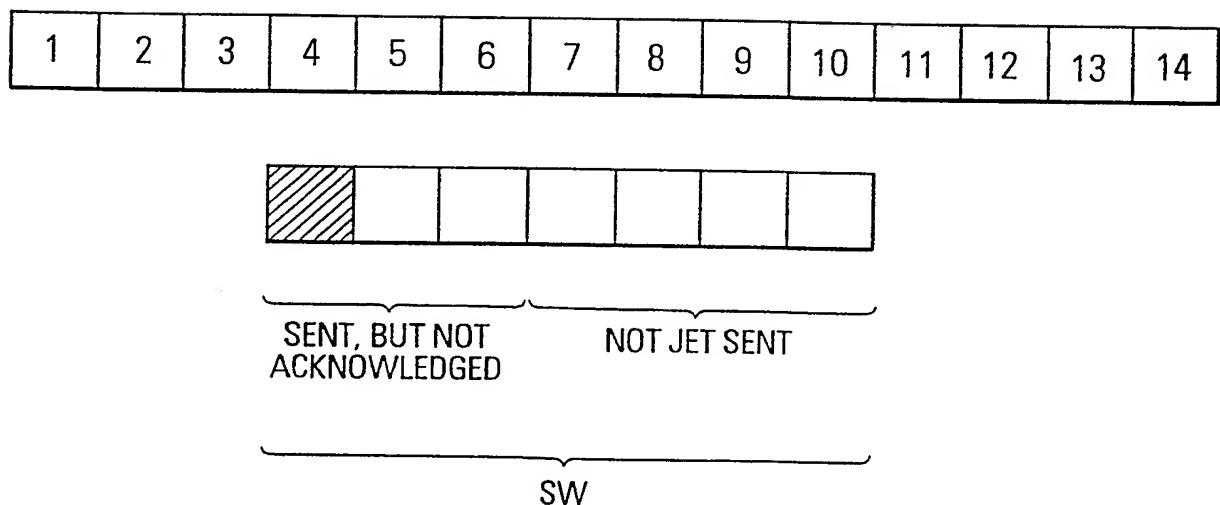
**FIG.8**

FIG.9



# INTERNATIONAL SEARCH REPORT

Inte:  national Application No

PCT/EP 99/07567

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 7 H04L1/18 H04L1/00

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category <sup>o</sup>	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>EP 0 743 764 A (NIPPON TELEGRAPH &amp; TELEPHONE) 20 November 1996 (1996-11-20)  abstract  figures 2,4,6,7,10  column 1, line 53 -column 3, line 11  column 3, line 55 -column 4, line 4</p> <p>---</p> <p style="text-align: center;">-/--</p>	1-28

Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

<sup>o</sup> Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
8 December 1999	15/12/1999
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer  Langinieux, F

## INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 99/07567

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 768 806 A (AT & T CORP) 16 April 1997 (1997-04-16) abstract column 2, line 28 - line 43 column 2, line 54 - line 56 column 7, line 26 - line 39 column 23, line 9 - line 40 column 23, line 46 - line 54 column 24, line 29 - line 32 column 25, line 52 -column 26, line 6 column 27, line 42 -column 28, line 10 figures 7,20B,21 figures 23-26 ----	1-28
A	US 5 497 371 A (ELLIS JOHN G ET AL) 5 March 1996 (1996-03-05) abstract column 4, line 35 - line 54 column 5, line 8 - line 20 figures 2,3 ----	1-28
A	GB 2 320 869 A (LUCENT TECHNOLOGIES INC) 1 July 1998 (1998-07-01) abstract figure 3 ----	1-28
A	EP 0 790 713 A (LUCENT TECHNOLOGIES INC) 20 August 1997 (1997-08-20) abstract page 6, line 46 - line 57 page 3, line 27 - line 39 -----	1-28

**INTERNATIONAL SEARCH REPORT**

Information on patent family members

Inte...	nal Application No
PCT/EP 99/07567	

Patent document cited in search report	Publication date	Patent family member(s)			Publication date
EP 0743764	A 20-11-1996	CA 2175394	A	20-11-1996	
		CN 1141539	A	29-01-1997	
		JP 9046766	A	14-02-1997	
		US 5721742	A	24-02-1998	
EP 0768806	A 16-04-1997	US 5717689	A	10-02-1998	
		CA 2184417	A	11-04-1997	
		JP 9130407	A	16-05-1997	
US 5497371	A 05-03-1996	CA 2172263	A	04-05-1995	
		WO 9512265	A	04-05-1995	
		DE 69416849	D	08-04-1999	
		DE 69416849	T	08-07-1999	
		EP 0726002	A	14-08-1996	
		JP 2942875	B	30-08-1999	
		JP 8510888	T	12-11-1996	
GB 2320869	A 01-07-1998	US 5983382	A	09-11-1999	
		CA 2222253	A	30-06-1998	
		JP 10210016	A	07-08-1998	
EP 0790713	A 20-08-1997	US 5722051	A	24-02-1998	
		CA 2196114	A	14-08-1997	
		JP 9233021	A	05-09-1997	